US010770674B2

(12) **United States Patent**
Lee et al.

(10) **Patent No.: US 10,770,674 B2**
(45) **Date of Patent: Sep. 8, 2020**

(54) **OLED LIGHTING APPARATUS**

(71) Applicant: **LG DISPLAY CO., LTD.**, Seoul (KR)

(72) Inventors: **Kyu-Hwang Lee**, Seoul (KR); **Taejoon Song**, Paju-si (KR); **Chulho Kim**, Incheon (KR); **Hwankeon Lee**, Daejeon (KR)

(73) Assignee: **LG DISPLAY CO., LTD.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 16 days.

(21) Appl. No.: **16/197,301**

(22) Filed: **Nov. 20, 2018**

(65) **Prior Publication Data**

US 2019/0165297 A1 May 30, 2019

(30) **Foreign Application Priority Data**

Nov. 28, 2017 (KR) 10-2017-0159846

(51) **Int. Cl.**
H01L 51/52 (2006.01)
G09G 3/3225 (2016.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01L 51/5203*** (2013.01); ***G09G 3/3225*** (2013.01); ***H01L 27/3276*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01L 51/5203; H01L 27/3276; H01L 51/5253; H01L 51/5237; H01L 2251/5361;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

2009/0121323 A1 5/2009 Kwon et al.
2013/0207094 A1 8/2013 Tchakarov
(Continued)

FOREIGN PATENT DOCUMENTS

CN 104393009 A 3/2015
JP 2013-251255 A 12/2013
(Continued)

OTHER PUBLICATIONS

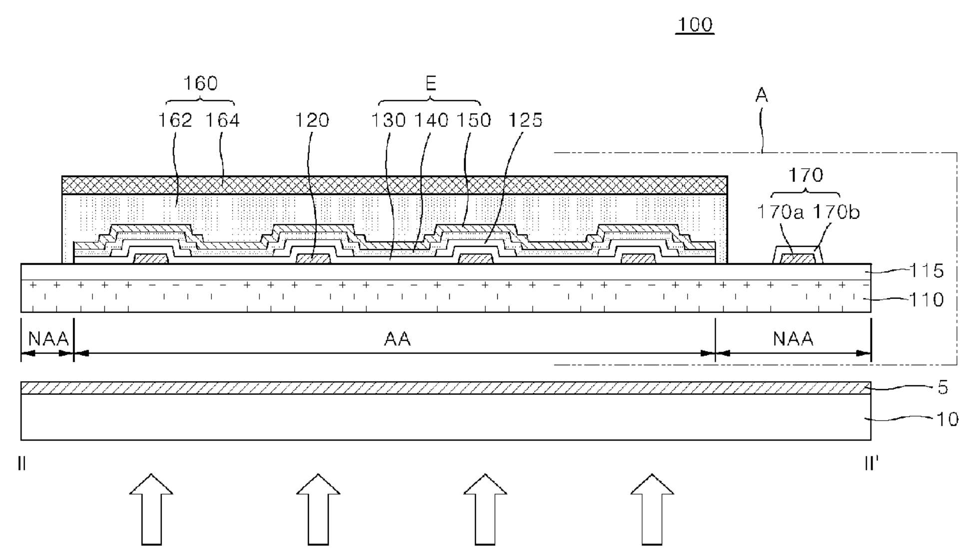
Taiwanese Office Action dated Sep. 20, 2019 issued in a related Taiwanese Patent Application No. 107142445 (7 pages) and English language translation (5 pages).
(Continued)

Primary Examiner — Muhammad N Edun
(74) *Attorney, Agent, or Firm* — Polsinelli PC

(57) **ABSTRACT**

Disclosed herein is an OLED lighting apparatus which can achieve both improvement in reliability and reduction in manufacturing cost. In the OLED lighting apparatus, an encapsulation layer is disposed over the active area and the non-active area on a buffer layer, such that a pad disposed in the non-active area of the buffer layer can be stably secured by the encapsulation layer bonded thereto. Accordingly, upon tape automated bonding between an FPCB substrate with a COF tape attached thereto and a via electrode, the COF tape does not directly contact the pad but contacts the via electrode connected to the pad, particularly a connection terminal of the via electrode disposed on an upper surface of the encapsulation layer, thereby establishing electrical connection between the FPCB substrate and the via electrode. In this way, the connection terminal of the via electrode is electrically connected to the FPCB substrate via the COF tape, whereby a signal from the outside can be applied to the pad connected to the via electrode.

17 Claims, 6 Drawing Sheets



(51) **Int. Cl.**
H01L 27/32 (2006.01)
H01L 51/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H01L 51/5212*** (2013.01); ***H01L 51/5237*** (2013.01); ***H01L 51/5253*** (2013.01); *H01L 51/003* (2013.01); *H01L 2251/5338* (2013.01); *H01L 2251/5361* (2013.01)

(58) **Field of Classification Search**
CPC H01L 51/003; H01L 2251/5338; H01L 51/5212; G09G 3/3225
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2013/0240855	A1	9/2013	Chida et al.	
2016/0062520	A1*	3/2016	Choi	G06F 3/0412 345/174
2016/0276630	A1	9/2016	Farrnbacher et al.	
2017/0005155	A1*	1/2017	You	H01L 27/3258
2017/0125505	A1*	5/2017	Oh	H01L 51/52
2018/0061898	A1*	3/2018	Oh	H01L 27/322

FOREIGN PATENT DOCUMENTS

JP	2015-005737	A	1/2015
JP	2015-220090	A	12/2015
KR	10-1372914	B1	3/2014
KR	10-2015-0063669	A	6/2015
KR	10-2016-0083641	A	7/2016
TW	201246528	A	11/2012
WO	2014/188895	A1	11/2014

OTHER PUBLICATIONS

Japanese Office Action dated Oct. 15, 2019 issued in a related Japanese Patent Application No. 2018-218646 (11 pages).

European Search Report dated Mar. 29, 2019 issued in connection with the corresponding European patent application EP 18 20 7732.1. 9 pages.

* cited by examiner

FIG. 1

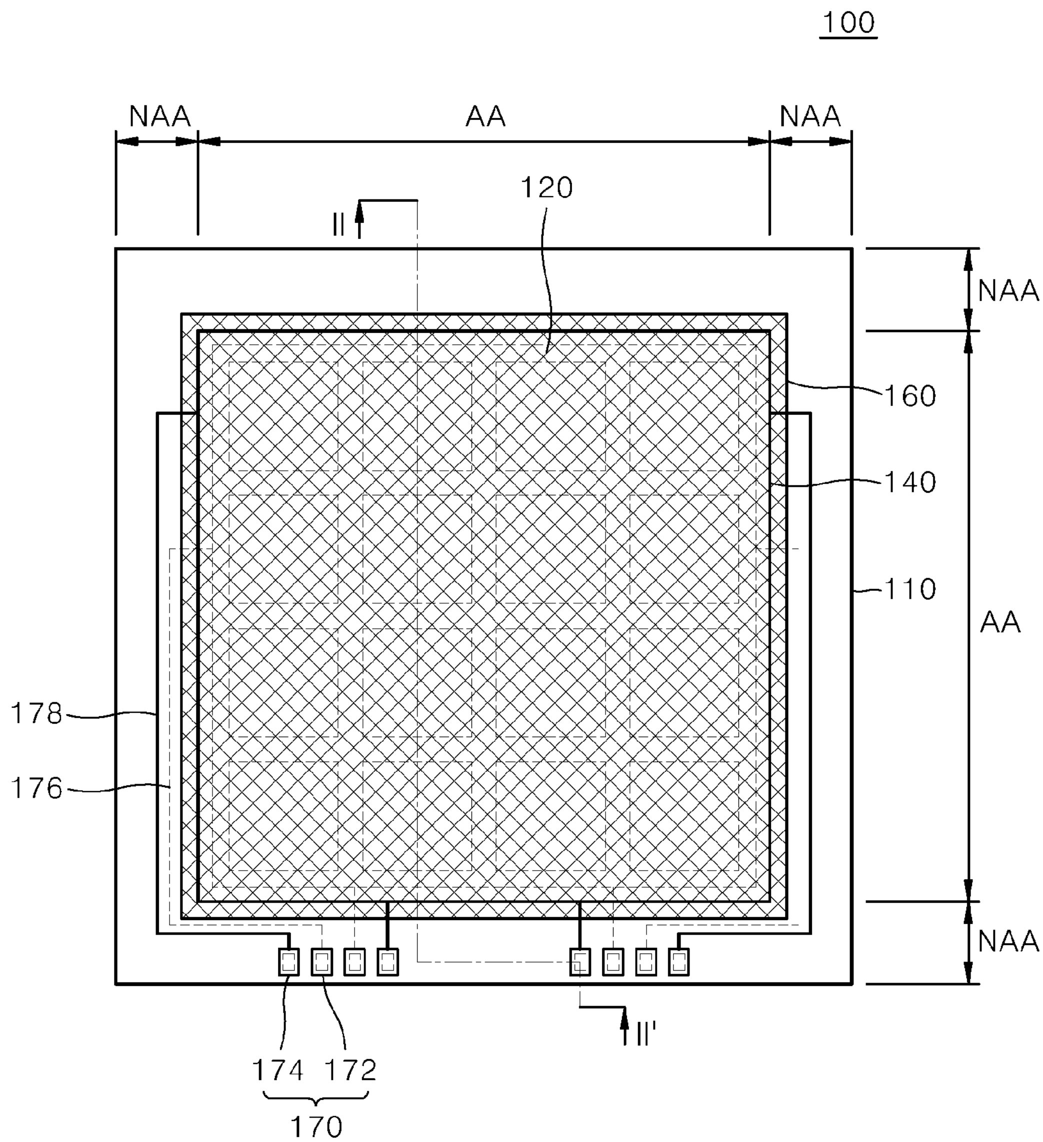

100
NAA
AA
NAA
II
120
160
140
110
AA
NAA
NAA
178
176
II'
174
172
170

FIG. 2

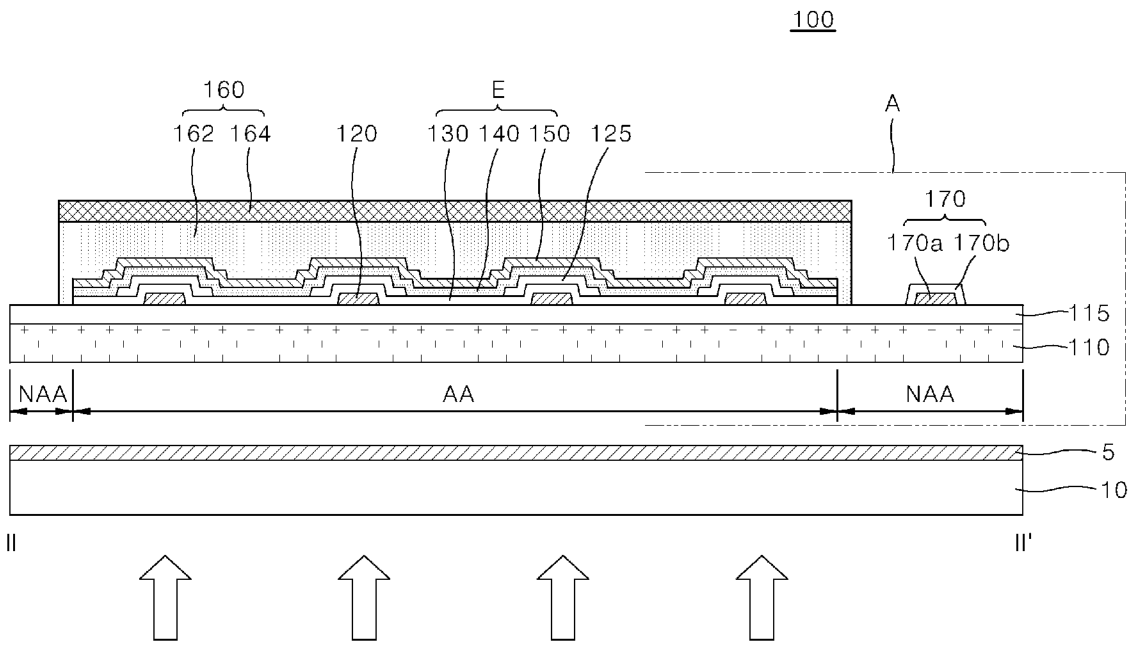

100
160
162 164
120
E
130 140 150
125
A
170
170a 170b
115
110
NAA
AA
NAA
5
10
II
II'

FIG. 3

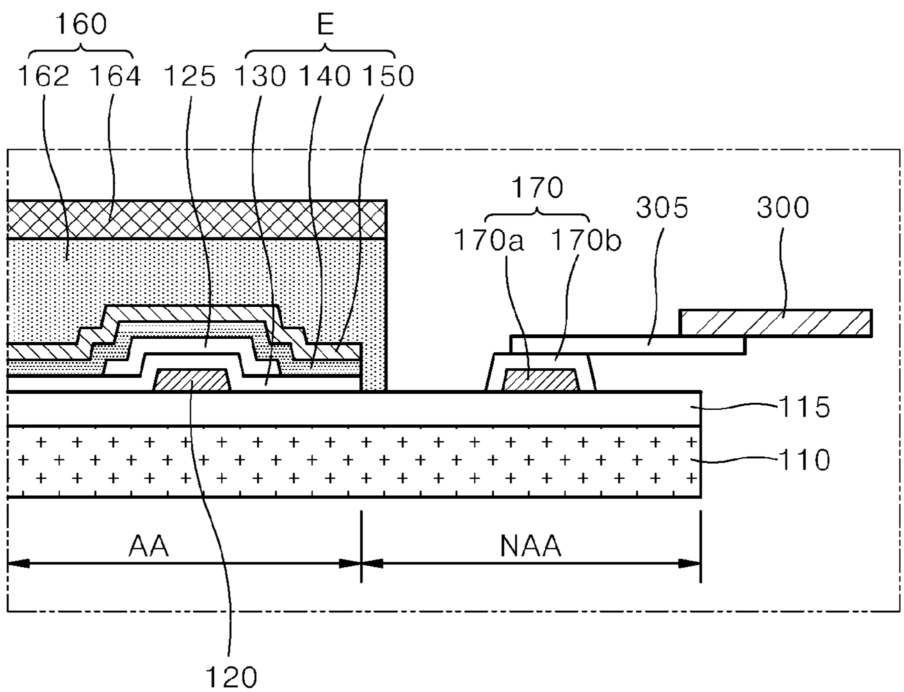

160
162 164
125
E
130 140 150
170
170a 170b
305
300
115
110
AA
NAA
120

FIG. 4

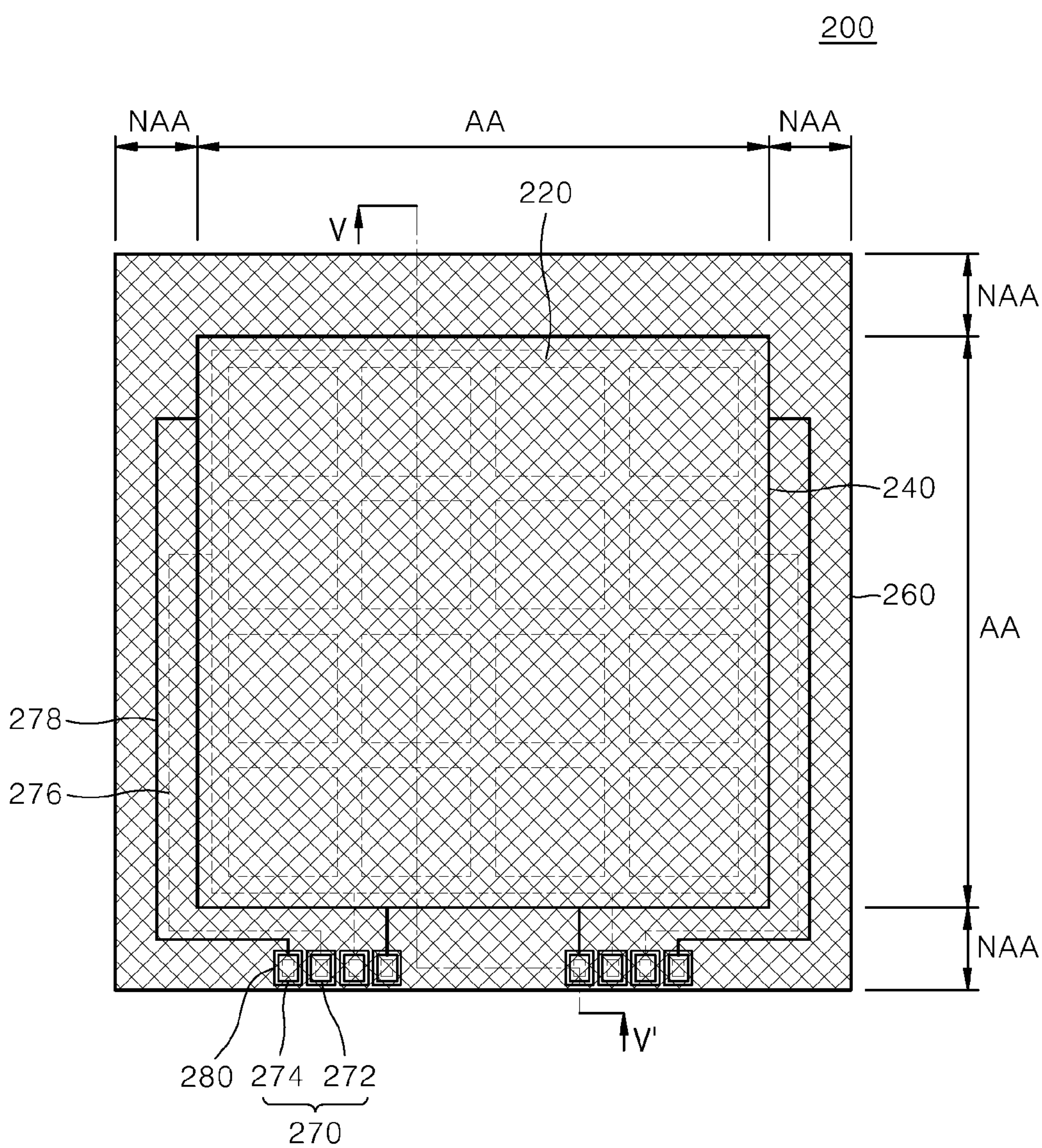


FIG. 5

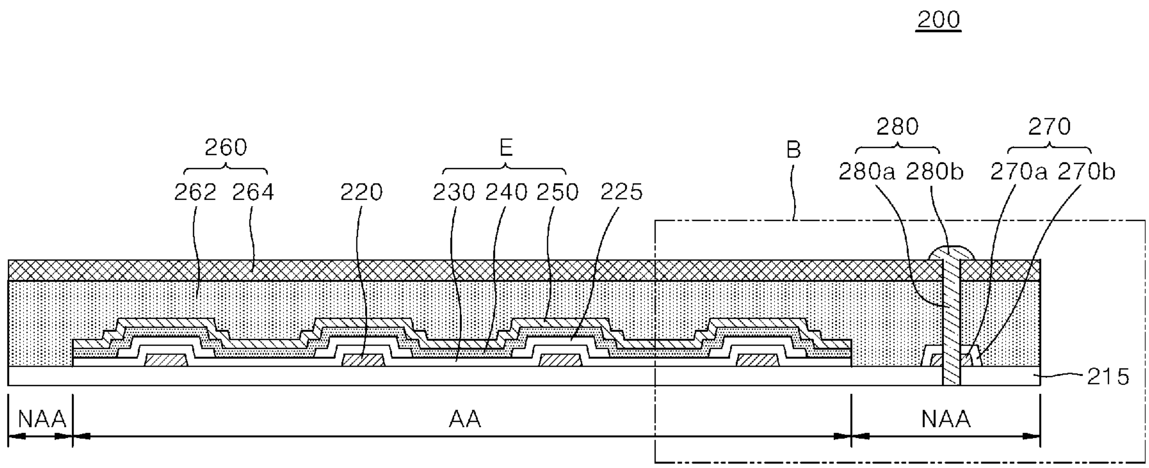

200
280
270
260
E
B
262 264
220
230 240 250
225
280a 280b
270a 270b
215
NAA
AA
NAA

FIG. 6

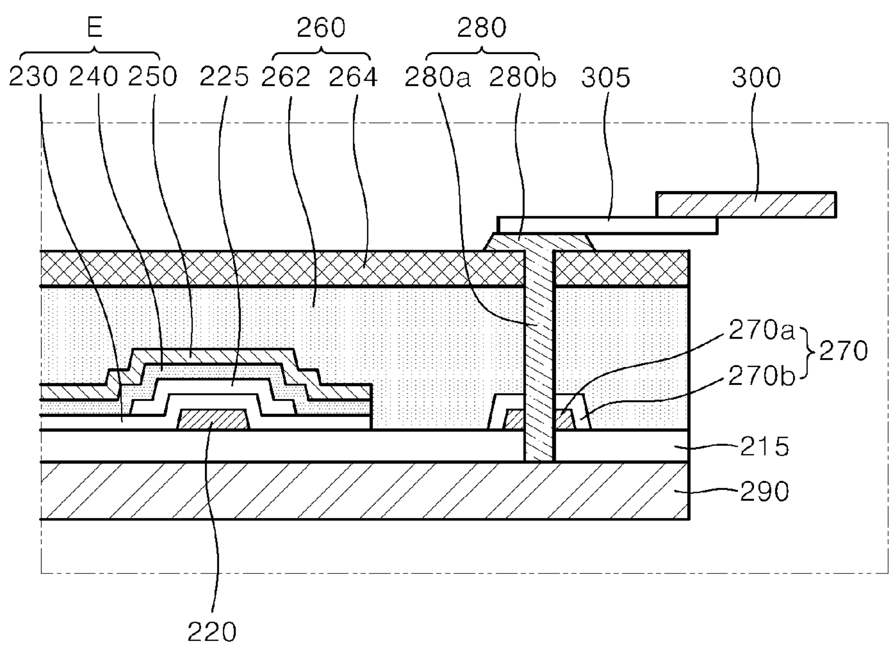

E
260
280
230 240 250
225
262 264
280a 280b
305
300
270a
270
270b
215
290
220

FIG. 7

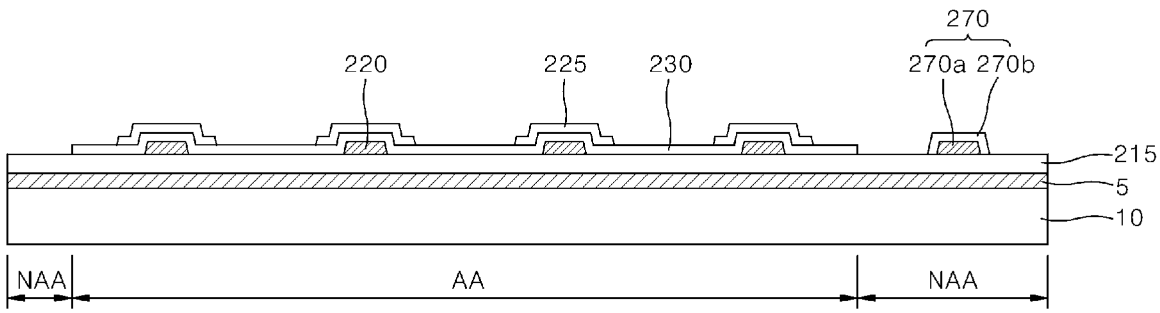


FIG. 8

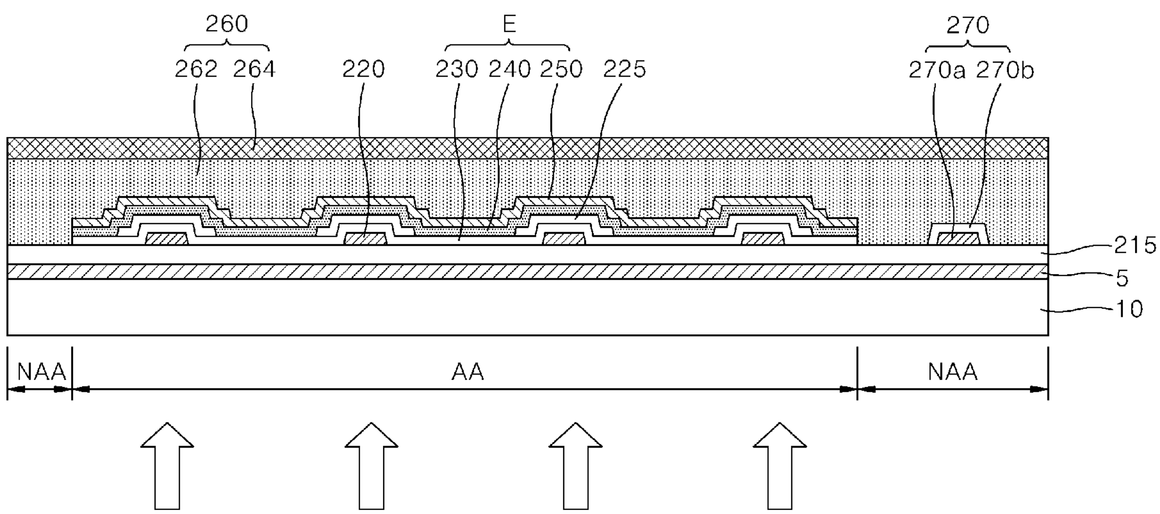


FIG. 9

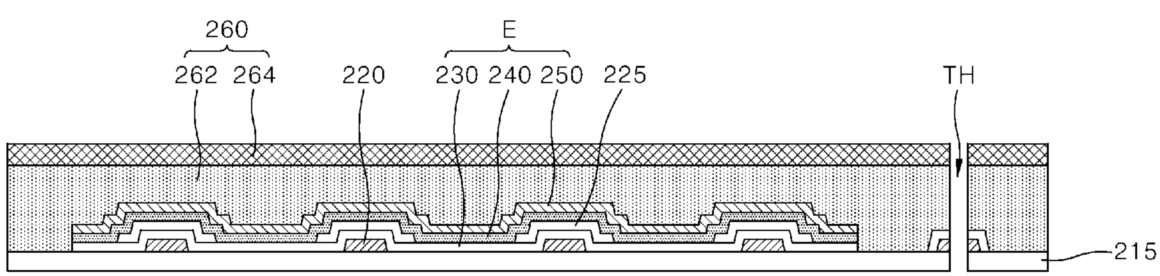


FIG. 10

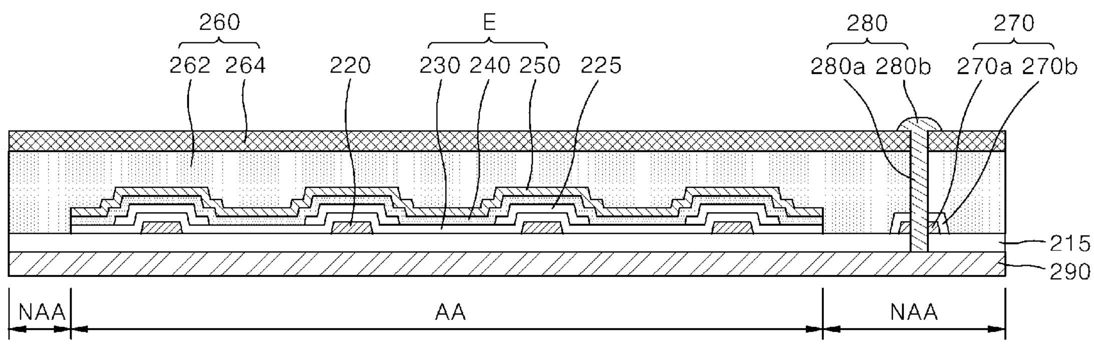
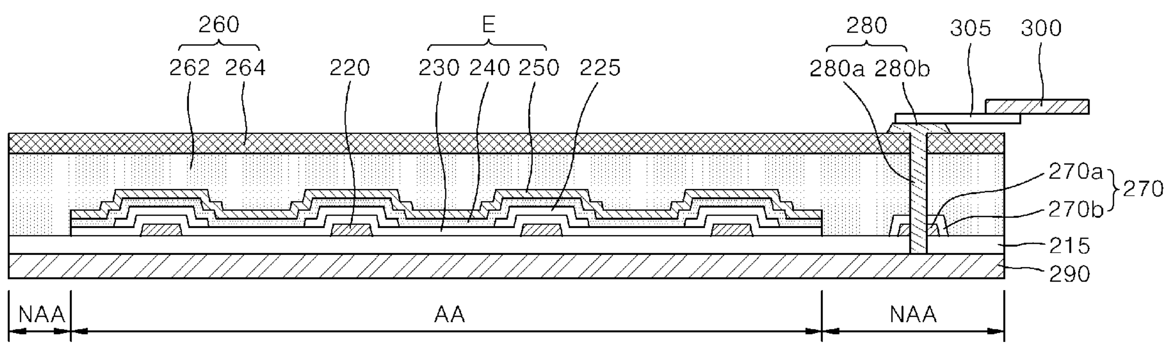

260
262 264
220
E
230 240 250
225
280
280a 280b
270
270a 270b
215
290
NAA
AA
NAA

FIG. 11


260
262 264
220
E
230 240 250
225
280
280a 280b
305
300
270a
270b
270
215
290
NAA
AA
NAA

OLED LIGHTING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of the Korean Patent Application No. 10-2017-0159846 filed on Nov. 28, 2017, which is hereby incorporated by reference in its entirety.

BACKGROUND

Field of the Disclosure

The present disclosure relates to a display device, and more particularly, to an organic light emitting diode (OLED) lighting apparatus. Although the present disclosure is suitable for a wide scope of applications, it is particularly suitable for improving reliability of the organic light emitting diode (OLED) lighting apparatus and reducing manufacturing costs.

Description of the Background

Currently, fluorescent lamps and incandescent lamps are mainly used as a lighting apparatus. The incandescent lamps have a problem of a very low energy efficiency, despite a high color rendering index, and the fluorescent lamps have a problem of a low color rendering index and contain mercury causing environmental pollution, despite a good energy efficiency.

Accordingly, light emitting diodes (LEDs) have been proposed as a lighting apparatus capable of replacing fluorescent lamps or incandescent lamps. Such a light emitting diode is formed of an inorganic luminescent material, and luminous efficacy thereof has a maximum value in the blue wavelength band and decreases toward the red wavelength band and the green wavelength band, which has the highest visibility. Accordingly, a method of obtaining white light by combining a red LED with a green LED and a blue LED has a problem of reduction in luminous efficacy. Such a method also has a problem of reduction in color rendering properties due to a small width of an emission peak of each LED.

In order to overcome such problems, there has been proposed a lighting apparatus configured to emit white light through combination of a blue LED with yellow phosphors instead of combining a red LED with a green LED and a blue LED. This is because a method of obtaining white light through combination of a blue LED having high luminous efficacy with phosphors that emit yellow light when irradiated with blue light from the blue LED is more efficient than use of a green LED, which has low luminous efficacy.

However, such a lighting apparatus configured to emit white light through combination of the blue LED with the yellow phosphors has limited luminous efficacy due to low luminous efficacy of the yellow phosphors.

In order to solve such a problem of reduction in luminous efficiency, there has been proposed an OLED lighting apparatus using an organic light emitting device formed of an organic luminescent material. Generally, an organic light emitting device has relatively good luminous efficacy in the green and red wavelength regions, as compared with an inorganic light emitting device. In addition, such an organic light emitting device exhibits improved color rendering properties due to relatively wide emission peak in the blue, red, and green wavelength regions, as compared with an inorganic light emitting device, and thus can emit light similar to sunlight.

SUMMARY

An aspect of the present disclosure is aimed at providing an OLED lighting apparatus which can achieve both improvements in reliability and reduction in manufacturing costs.

For this purpose, an OLED lighting apparatus according to the present disclosure omits a substrate and instead has an encapsulation layer disposed over an active area and a non-active area on a buffer layer.

Thus, the OLED lighting apparatus according to the aspect of the present disclosure includes a via electrode passing through the encapsulation layer to be connected to a pad, thereby improving reliability of an organic light emitting device while achieving reduction in manufacturing costs.

In accordance with aspects of the present disclosure, an OLED lighting apparatus includes an encapsulation layer disposed over an active area and a non-active area on a buffer layer to cover a second electrode and a pad.

In addition, the OLED lighting apparatus includes a via electrode passing through the encapsulation layer in the non-active area to be connected to the pad.

The via electrode may include: a penetration portion passing through the encapsulation layer, the pad, and the buffer layer in the non-active area to be connected to the pad; and a connection terminal disposed on an upper surface of the encapsulation layer in the non-active area to be connected to the penetration portion.

In the OLED lighting apparatus according to the aspects, since the encapsulation layer is disposed over the active area and the non-active area on the buffer layer, the pad disposed in the non-active area of the buffer layer can be stably secured by the encapsulation layer bonded thereto.

Accordingly, in the OLED lighting apparatus according to the aspects, upon tape automated bonding between an Flexible Printed Circuit Board (FPCB) substrate with a Chip on Film (COF) tape attached thereto and the via electrode, the COF tape does not directly contact the pad but contacts the via electrode connected to the pad, particularly the connection terminal of the via electrode disposed on the upper surface of the encapsulation layer, thereby establishing electrical connection between the FPCB substrate and the via electrode.

As a result, in the OLED lighting apparatus according to the aspects, the connection terminal of the via electrode is electrically connected to the FPCB substrate via the COF tape, such that a signal from the outside can be applied to the pad connected to the via electrode.

As such, according to the present disclosure, the OLED lighting apparatus includes the encapsulation layer disposed over the active area and the non-active area on the buffer layer, such that the pad disposed in the non-active area of the buffer layer can be stably secured by the encapsulation layer bonded thereto.

In addition, upon tape automated bonding between an FPCB substrate with a COF tape attached and a via electrode, the COF tape does not directly contact the pad but contacts the via electrode connected to the pad, particularly a connection terminal of the via electrode disposed on the upper surface of the encapsulation layer, thereby establishing electrical connection between the FPCB substrate and the via electrode.

In this way, the connection terminal of the via electrode is electrically connected to the FPCB substrate via the COF tape, whereby a signal from the outside can be applied to the pad connected to the via electrode.

Further, in the OLED lighting apparatus according to the aspect of the present disclosure, since tape automated bonding is performed after the pad disposed in the non-active area of the buffer layer is stably secured by the encapsulation layer, it is possible to omit a substrate formed of a transparent PI film, which would otherwise be disposed under the buffer layer, thereby reducing manufacturing costs.

Furthermore, since the OLED lighting apparatus according to the present disclosure does not require such a substrate, a method of forming auxiliary wires, an organic light emitting device and the like can be executed at a high temperature exceeding 350° C., thereby improving reliability of the organic light emitting device.

Furthermore, in the OLED lighting apparatus according to the present disclosure, the buffer layer formed as an inorganic layer such as SiO_x or SiN_x is also exposed to the high temperature process exceeding 350° C. and thus can have improved properties in terms of strength and hardness.

In another aspect, an OLED lighting apparatus having an active area and a non-active area includes a buffer layer; an encapsulation layer disposed over the buffer layer; a pad connected to a first electrode and a second electrode of an organic light emitting device and disposed in the non-active area; and a connection terminal disposed on an upper surface of the encapsulation layer in the non-active area, wherein the pad is connected to the connection terminal.

In another aspect, an OLED lighting apparatus having an active area and a non-active area includes a buffer layer; an auxiliary wire disposed on the buffer layer; an organic light emitting device comprising a first electrode disposed on the auxiliary wire to be connected to the auxiliary wire and an organic light emitting layer and a second electrode stacked on the first electrode; an encapsulation layer disposed over the buffer layer and having an opening.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other aspects, features and advantages of the present disclosure will become apparent from the following description of aspects given in conjunction with the accompanying drawings:

FIG. **1** is a plan view of an OLED lighting apparatus according to a first aspect of the present disclosure;

FIG. **2** is a cross-sectional view taken along line II-II' of FIG. **1**;

FIG. **3** is an enlarged cross-sectional view of portion A of FIG. **2**;

FIG. **4** is a plan view of an OLED lighting apparatus according to a second aspect of the present disclosure;

FIG. **5** is a cross-sectional view taken along line V-V' of FIG. **4**;

FIG. **6** is an enlarged sectional view of portion B of FIG. **5**; and

FIG. **7** to FIG. **11** are cross-sectional views illustrating a method of manufacturing the OLED lighting apparatus according to a second aspect of the present disclosure.

DETAILED DESCRIPTION

Hereinafter, aspects of the present disclosure will be described in detail with reference to the accompanying drawings. It should be understood that the present disclosure is not limited to the following aspects and may be embodied in different ways, and that the aspects are given to provide complete disclosure of the present disclosure and to provide thorough understanding of the present disclosure to those skilled in the art. Description of known functions and constructions which can unnecessarily obscure the subject matter of the present disclosure will be omitted. Like components will be denoted by like reference numerals throughout the specification.

Now, an OLED lighting apparatus according to a first aspect of the present disclosure will be described in detail with reference to the accompanying drawings. FIG. **1** is a plan view of an OLED lighting apparatus according to a first aspect of the present disclosure and FIG. **2** is a cross-sectional view taken along line II-II' of FIG. **1**.

Referring to FIG. **1** and FIG. **2**, an OLED lighting apparatus **100** according to a first aspect includes a buffer layer **115** disposed on a substrate **110** and an organic light emitting device E disposed on the buffer layer **115**.

The organic light emitting device E includes a first electrode **130** disposed on the buffer layer **115**, an organic light emitting layer **140** disposed on the first electrode **130**, and a second electrode **150** disposed on the organic light emitting layer **140**. In the OLED lighting apparatus **100** having such a structure, the organic light emitting layer **140** emits light when a signal is applied to the first electrode **130** and the second electrode **150** of the organic light emitting device E, whereby light emission over the entire substrate **110** can be achieved.

Here, auxiliary wires **120** are arranged in matrix form on the substrate **110**. The auxiliary wires **120** are formed of metal having high electrical conductivity to allow uniform voltage to be applied to the first electrode **130** disposed over the entire area of the substrate **110**, whereby the OLED lighting apparatus **100** can emit light with uniform luminance even when implemented as a large lighting apparatus. The auxiliary wires **120** may be disposed between the buffer layer **115** and the first electrode **130** to directly contact the first electrode **130**.

The first electrode **130** is formed of a transparent conductive material, such as ITO, and advantageously transmits emitted light therethrough. However, the first electrode **130** has a drawback of much higher electrical resistance than metals. As a result, when the OLED lighting apparatus **100** is implemented as a large lighting apparatus, current spreading in a wide active area AA may not be uniform due to high resistance of the transparent conductive material. Such non-uniform current spreading makes it difficult for the large OLED lighting apparatus **100** to emit light with uniform luminance.

The auxiliary wires **120** may be arranged in the form of a matrix, mesh, hexagon, octagon, or circle having a small linewidth over the entire substrate **110** to allow uniform voltage to be applied to the first electrode **130** on the entire substrate **110**, such that the large area OLED lighting device **100** can emit light with uniform luminance.

Although the auxiliary wires **120** are shown as disposed beneath a lower surface of the first electrode **130**, the present disclosure may not be limited thereto and the auxiliary wires **120** may be disposed on an upper surface of the first electrode **130**. The auxiliary wires **120** may be formed of any one of Al, Au, Cu, Ti, W, Mo, Cr, and alloys thereof. The auxiliary wires **120** may have a monolayer structure or a multilayer structure.

The substrate **110** may be divided into a plurality of unit pixels by the auxiliary wires **120** arranged in matrix form. Since the auxiliary wires **120** have much lower resistance than the first electrode **130**, voltage for the first electrode **130** is applied to the first electrode **130** through the auxiliary wires **120** rather than being directly applied to the first electrode **130** via a first pad **172**. In this way, the first electrode **130** formed over the entire substrate **110** can be divided into the plurality of pixels by the auxiliary wires **120**.

Although the linewidth of the auxiliary wires can vary depending on the kind of metal used as a material for the auxiliary wires, the area of the OLED lighting apparatus **100**, the size of the pixel, and the like, the auxiliary wires **120** may have a linewidth of about 30 μm to about 70 μm.

In addition, the substrate **110** is provided thereon with a pad **170** that is connected to both the first electrode **130** and the second electrode **150** and receives voltage from the outside. For this purpose, the pad **170** may include a first pad **172** connected to the first electrode **130** and a second pad **174** connected to the second electrode **150**. The first pad **172** and the second pad **174** may be electrically connected to the first electrode **130** and the second electrode **150** through a first connection wire **176** and the second connection wire **178**, respectively.

Although the pad **170** is shown as disposed at one side of the substrate **110** in FIG. **1**, the present disclosure may not be limited thereto and the location and number of the pad **170** may be varied. For example, the pad **170** may be disposed at two opposite sides of the substrate **110** or at four sides of the substrate **110**. For example, the first pad **172** and the second pad **174** may be disposed at two opposite sides of the substrate **110** or at four sides of the substrate **110**.

Here, the pad **170** may include a pad electrode **170***a* disposed on the same layer as the auxiliary wires **120** and formed of the same material as the auxiliary wires **120** and a pad electrode terminal **170***b* disposed on the pad electrode **170***a* and formed of the same material as the first electrode **130**.

A protective layer **125** is disposed on the first electrode **130**. Specifically, the protective layer **125** is disposed on the first electrode **130** to cover the auxiliary wires **120**.

Since the auxiliary wires **120** are formed of an opaque metal, light is not emitted from regions in which the auxiliary wires **120** are formed. Accordingly, the protective layer **125** is disposed only on portions of an upper surface of the first electrode **130**, under which the auxiliary wires **120** are disposed, whereby light can be emitted only from light emitting regions of the pixels.

In an aspect, the protective layer **125** may be disposed between the first electrode **130** and the organic light emitting layer **140** to cover the auxiliary wire **120**.

In addition, the protective layer **125** may be formed to cover the auxiliary wires **120** to reduce step coverage caused by the auxiliary wires **120** such that the organic light emitting layer **140** and the second electrode **150** can be subsequently stacked in a stable manner without disconnection.

For this purpose, the protective layer **125** may be formed of an inorganic material, such as SiO_x and SiN_x. Alternatively, the protective layer **125** may be formed of an organic material, such as photoacryl, or may be formed as a plurality of layers including an inorganic layer and an organic layer.

The organic light emitting layer **140** and the second electrode **150** are sequentially disposed on the first electrode **130** and the protective layer **125**.

The organic light emitting layer **140** may be formed of an organic luminescent material that emits white light. For example, the organic light emitting layer **140** may include a blue organic light emitting layer, a red organic light emitting layer, and a green organic light emitting layer. Alternatively, the organic light emitting layer **140** may have a tandem structure including a blue light emitting layer and a yellow-green light emitting layer. However, it should be understood that the present disclosure is not limited thereto and the organic light emitting layer **140** may be configured in various ways.

Although not shown in the drawings, the organic light emitting device E may further include: an electron injection layer and a hole injection layer which inject electrons and holes into the organic light emitting layer **140**, respectively; an electron transport layer and a hole transport layer which transport injected electrons and holes to the organic light emitting layer; and a charge generation layer which generates charges such as electrons and holes.

The organic light emitting layer **140** may be formed of a material that receives holes and electrons from the hole transport layer and the electron transport layer, respectively, to emit light in the visible region through recombination of the holes and the electrons. Particularly, a material having good quantum efficiency for fluorescence or phosphorescence may be used. Examples of the material may include an 8-hydroxyquinoline aluminum complex (Alq_3), a carbazole compound, a dimerized styryl compound, BAlq, a 10-hydroxybenzoquinoline-metal compound, benzoxazole, benzthiazole, and benzimidazole compounds, and poly(p-phenylene vinylene) (PPV), without being limited thereto.

The second electrode **150** may be formed of a metal, such as Ca, Ba, Mg, Al, and Ag, or alloys thereof. Here, the substrate **110** is provided in a non-active region NAA thereof with the second pad **174** that is connected to the second electrode **150** to apply voltage to the second electrode **150**.

The first electrode **130**, the organic light emitting layer **140**, and the second electrode **150** constitute the organic light emitting device E. Here, the first electrode **130** is an anode of the organic light emitting device E and the second electrode **150** is a cathode of the organic light emitting device E. When voltage is applied between the first electrode **130** and the second electrode **150**, electrons and holes are injected into the organic light emitting layer **140** from the second electrode **150** and the first electrode **130**, respectively, thereby generating excitons in the organic light emitting layer **140**. As the excitons decay, light corresponding to energy difference between a lowest unoccupied molecular orbital (LUMO) and a highest occupied molecular orbital (HOMO) of the organic light emitting layer **140** is generated and emitted toward the substrate **110**. FIG. **3** is an enlarged cross-sectional view of portion A of FIG. **2**.

Referring to FIG. **2** and FIG. **3**, an encapsulation layer **160** covering the second electrode **150** of the organic light emitting device E is disposed in the active area AA on the substrate **110** having the organic light emitting device E formed thereon.

The encapsulation layer **160** may include an adhesive layer **162** and a base layer **164** disposed on the adhesive layer **162**. In this way, the encapsulation layer **160** including the adhesive layer **162** and the base layer **164** is disposed in the active region AA of the substrate **110** having the organic light emitting device E thereon such that the OLED lighting apparatus **100** can be sealed by the base layer **164** attached to the adhesive layer **162**.

Here, the adhesive layer **162** may be formed of a photo-curable adhesive or a heat-curable adhesive. The base layer **164** serves to prevent penetration of moisture or air from the outside and may be formed of any material so long as the material can perform this function. For example, the base layer **164** may be formed of a polymeric material, such as polyethylene terephthalate (PET), or a metallic material, such as an aluminum foil, an Fe—Ni alloy, or an Fe—Ni—Co alloy.

In the first aspect, the encapsulation layer **160** is disposed to only cover the active area AA on the substrate **110** so as to expose the pad **170** disposed in a non-active area NAA such that the pad **170** can be connected to an FPCB substrate **300**, whereby a signal coming from the outside through the FPCB substrate **300** can be applied to each of the first electrode **130** and the second electrode **150** via the pad **170**.

Accordingly, the organic light emitting device E disposed in the active area AA on the substrate **110** is sealed by the encapsulation layer **160** and the pad **170** disposed in the non-active area NAA on the substrate **110** is exposed to the outside. In this way, the pad **170** exposed to the outside of the encapsulation layer **160** is connected to the FPCB substrate **300** via a COF tape **305**.

Here, the FPCB substrate **300** is electrically connected to the pad **170** by tape automated bonding via the COF tape **305**. In the first aspect, since the encapsulation layer **160** is not disposed in the non-active region NAA of the substrate **110** in which the pad **170** is disposed, the substrate **110** under the buffer layer **115** serves to stably support the pad **170**. Accordingly, the OLED lighting apparatus **100** according to the first aspect necessarily requires the substrate **110**, which is formed of a flexible polymeric material.

The OLED lighting apparatus **100** according to the first aspect using the organic light emitting device formed of an organic luminescent material has relatively good luminous efficacy in the green and red wavelength regions, as compared with a lighting apparatus using an inorganic light emitting device, and exhibits improved color rendering properties due to relatively wide emission peak in the blue, red, and green wavelength regions, thereby emitting light similar to sunlight.

However, for the OLED lighting apparatus **100** according to the first aspect, the substrate **110** is formed of a transparent, soft and flexible polymeric material, such as plastic materials, to provide flexibility to the OLED lighting apparatus.

Accordingly, the OLED lighting apparatus **100** according to the first aspect is fabricated on a carrier glass **10** as shown in FIG. **2**, followed by separation of the substrate **110**, that is, the OLED lighting apparatus **100**, from the carrier glass **10** through irradiation with laser beams. Here, a sacrificial layer **5** formed of silicone is disposed between the carrier glass **10** and the substrate **110** to facilitate separation of the substrate through irradiation with laser beams.

For the OLED lighting apparatus **100** according to the first aspect, among flexible polymeric materials, a polyimide (PI) film having good heat resistance is used as a material for the substrate **110**. However, such a PI film is much more expensive than other polymeric materials, causing increase in manufacturing cost.

Further, since the PI film is likely to be damaged at a high temperature exceeding 350° C., exceeding a heat-resistant temperature of PI, a method of forming the auxiliary wires **120**, the organic light emitting device E and the like is performed under limited conditions, that is, at a temperature below 350° C., thereby causing deterioration in reliability of the organic light emitting device E.

In order to solve such a problem, an OLED lighting apparatus according to a second aspect omits a substrate and instead includes: an encapsulation layer disposed over the entire region of a buffer layer including an active area and a non-active area; and a via electrode passing through the encapsulation layer to be electrically connected to a pad, thereby improving reliability of an organic light emitting device while reducing manufacturing costs.

Next, an OLED lighting apparatus according to a second aspect of the present disclosure will be described with reference to the accompanying drawings.

FIG. **4** is a plan view of an OLED lighting apparatus according to a second aspect of the present disclosure, which can achieve both improvement in reliability and reduction in manufacturing costs, and FIG. **5** is a cross-sectional view taken along line V-V' of FIG. **4**.

Referring to FIG. **4** and FIG. **5**, an OLED lighting apparatus **200** according to the second aspect includes: a buffer layer **215**; auxiliary wires **220**; an organic light emitting device E; a pad **270**; an encapsulation layer **260**; and a via electrode **280**.

The buffer layer **215** has an active region AA and a non-active region NAA. The buffer layer **215** serves to block penetration of moisture or air from below. For this purpose, the buffer layer **215** may be formed of an inorganic material, such as SiO_x or SiN_x. Particularly, the OLED lighting apparatus **200** according to the second aspect omits a substrate which would otherwise be disposed under the buffer layer **215**, thereby allowing a method of forming the auxiliary wires **220**, the organic light emitting device E and the like to be performed at a high temperature exceeding 350° C., thereby improving reliability of the organic light emitting device E while reducing manufacturing costs. Further, since the buffer layer **215** formed of an inorganic material, such as SiO_x or SiN_x, is exposed to a high temperature exceeding 350° C., the buffer layer can exhibit improved properties in terms of strength and hardness.

The auxiliary wires **220** are disposed in the active area AA on the buffer layer **215**. The auxiliary wires **120** may be arranged in the form of a matrix, mesh, hexagon, octagon, or circle having a small linewidth over the active area AA of the buffer layer **215** to allow uniform voltage to be applied to the first electrode **230**, whereby the OLED lighting apparatus **200** can emit light with uniform luminance when implemented as a large lighting apparatus.

Although the auxiliary wires **220** are shown as disposed beneath a lower surface of the first electrode **230**, it should be understood that the present disclosure is not limited thereto and the auxiliary wires **220** may be disposed on an upper surface of the first electrode **230**. The auxiliary wires **120** may be formed of any one selected from Al, Au, Cu, Ti, W, Mo, Cr, and alloys thereof. The auxiliary wires **220** may have a monolayer structure or a multilayer structure.

The buffer layer **215** may be divided into a plurality of unit pixels by the auxiliary wires **220** arranged in matrix form. Since the auxiliary wires **220** have a very low resistance, as compared with the first electrode **230**, voltage for the first electrode **230** is applied to the first electrode **230** through the auxiliary wires **220** rather than being applied directly to the first electrode **230** via a first pad **272**. Thus, the first electrode **230** formed over the entire buffer layer **215** can be divided into a plurality of pixels by the auxiliary wires **220**.

The auxiliary wires **220** may have a linewidth of about 30 μm to about 70 μm, although the linewidth of the auxiliary wires can vary depending on the kind of metal used as a material for the auxiliary wires, the area of the OLED lighting apparatus **200**, the size of the pixel, and the like.

The organic light emitting device E is disposed on the auxiliary wires **220**. The organic light emitting device E includes a first electrode **230** disposed on the auxiliary wires **220** to be directly connected to the auxiliary wires **220**, an organic light emitting layer **240** disposed on the first electrode **230**, and a second electrode **250** disposed on the organic light emitting layer **240**.

The organic light emitting layer **240** may be formed of an organic luminescent material that emits white light. For example, the organic light emitting layer **240** may be composed of a blue organic light emitting layer, a red organic light emitting layer, and a green organic light emitting layer. Alternatively, the organic light emitting layer **240** may have a tandem structure including a blue light emitting layer and a yellow-green light emitting layer. However, it should be understood that the present disclosure is not limited thereto and the organic light emitting layer **240** may be configured in various ways.

Although not shown, the organic light emitting device E may further include: an electron injection layer and a hole injection layer that inject electrons and holes into the organic light emitting layer **240**, respectively; an electron transport layer and a hole transport layer that transport the injected electrons and holes to the organic light emitting layer; and a charge generation layer that generates charges such as electrons and holes.

The organic light emitting layer **240** may be formed of a material that receives holes and electrons from the hole transport layer and the electron transport layer, respectively, to emit light in the visible region through recombination of the holes and the electrons. Particularly, a material having good quantum efficiency for fluorescence or phosphorescence may be used. Examples of the material may include an 8-hydroxyquinoline aluminum complex (Alq_3), a carbazole compound, a dimerized styryl compound, BAlq, a 10-hydroxybenzoquinoline-metal compound, benzoxazole, benzthiazole, and benzimidazole compounds, and poly(p-phenylenevinylene) (PPV), without being limited thereto.

In addition, the OLED lighting apparatus **200** according to the second aspect may further include a protective layer **225** disposed between the first electrode **230** and the organic light emitting layer **240** to cover the auxiliary wires **220**. The protective layer **225** may be formed on the first electrode **230** to surround the auxiliary wires **220**, thereby reducing level difference caused by the auxiliary wires **220**. As a result, the organic light emitting layer **240** and the second electrode **250** can be stably stacked on the protective layer **225** without disconnection.

For this purpose, the protective layer **225** may be formed as an inorganic layer such as SiO_x or SiN_x. Alternatively, the protective layer **225** may be formed as an organic layer such as photoacryl, or may be formed as a plurality of layers including an inorganic layer and an organic layer.

The pad **270** is connected to the first electrode **230** and the second electrode **250** and disposed in a non-active area NAA. That is, the pad **270** is electrically connected to the first electrode **230** and the second electrode **250** and receives voltage from the outside. For this purpose, the pad **270** may include a first pad **272** connected to the first electrode **230** and a second pad **274** connected to the second electrode **250**. The first pad **272** and the second pad **274** may be electrically connected to the first electrode **230** and the second electrode **250** through a first connection wire **276** and the second connection wire **278**, respectively.

Although the pad **270** is shown as disposed at one side of the buffer layer **215** in FIG. **4**, it should be understood that the present disclosure is not limited thereto and the location and number of the pad **270** may be varied. For example, the pad **270** may be disposed at two opposite sides of the buffer layer **215** or may be disposed at four sides of the buffer layer **215**. For example, the first pad **272** and the second pad **274** may be disposed at two opposite sides of the buffer layer **215** or may be disposed at four sides of the buffer layer **215**.

Here, the pad **270** may include a pad electrode **270***a* disposed on the same layer as the auxiliary wires **220** and formed of the same material as the auxiliary wires **220** and a pad electrode terminal **270***b* disposed on the pad electrode **270***a* and formed of the same material as the first electrode **230**. Here, the pad electrode terminal **270***b* is disposed on upper and side surfaces of the pad electrode **270***a* to surround the upper and side surfaces of the pad electrode **270***a*.

In the second aspect, the encapsulation layer **260** is disposed over an active area AA and a non-active area NAA on the buffer layer **215** to cover the second electrode **250** and the pad **270**. That is, the encapsulation layer **260** may have the same area as the buffer layer **215** to cover all of the active area AA and the non-active area NAA of the buffer layer **215** having the pad **270** and the organic light emitting device E formed thereon.

In this way, the encapsulation layer **260** is disposed over the active area AA and the non-active area NAA of the buffer layer **215**, whereby the pad **270** disposed in the non-active area NAA of the buffer layer **215** can be stably secured by the encapsulation layer **260** bonded thereto. Accordingly, the OLED lighting apparatus according to the second aspect can omit a substrate which would otherwise be disposed under the buffer layer **215**.

The encapsulation layer **260** may include an adhesive layer **262** and a base layer **264** disposed on the adhesive layer **262**. In this way, the encapsulation layer **260** including the adhesive layer **262** and the base layer **264** is disposed in the active area AA of the buffer layer **215** having the organic light emitting device E formed thereon, such that the OLED lighting apparatus **200** can be sealed by the base layer **264** attached via the adhesive layer **262**.

Here, the adhesive layer **262** may be formed of a photocurable adhesive or a heat-curable adhesive. The base layer **264** serves to prevent penetration of moisture or air from the outside and may be formed of any suitable material for performing this function. For example, the base layer **264** may be formed of a polymeric material such as polyethylene terephthalate (PET) or a metallic material such as an aluminum foil, an Fe—Ni alloy, or an Fe—Ni—Co alloy.

The via electrode **280** passes through the encapsulation layer **260** in the non-active area NAA to be connected to the pad **270**.

The via electrode **280** includes a penetration portion **280***a* and a connection terminal **280***b*.

The penetration portion **280***a* of the via electrode **280** is disposed to pass through the encapsulation layer **260**, the pad **270**, and the buffer layer **215** in the non-active area NAA to be electrically connected to the pad **270**. Thus, the penetration portion **280***a* of the via electrode **280** is electrically connected to the pad **270** at the center of the pad **270** in a lateral-contact geometry.

The connection terminal **280***b* of the via electrode **280** is disposed on an upper surface of the encapsulation layer **260** in the non-active area NAA to be connected to the penetration portion **280***a* of the via electrode **280**. Accordingly, the connection terminal **280***b* of the via electrode **280** is disposed on the upper surface of the encapsulation layer **260** to be exposed to the outside.

The via electrode **280** may be formed of a metallic material having good electrical conductivity. For example, the via electrode **280** may be formed of at least one metal paste selected from among Ag, Al, Cu, and Au.

FIG. **6** is an enlarged sectional view of portion B of FIG. **5**, which will be described in conjunction with FIG. **5**.

Referring to FIG. **5** and FIG. **6**, the OLED lighting apparatus **200** according to the second aspect may further include a protective film **290** disposed under the buffer layer **215** to protect the buffer layer **215**. The protective film **290** disposed under the buffer layer **215** may not be necessarily provided and may be omitted if necessary.

Since the protective film **290** is attached to a lower surface of the buffer layer **215** after formation of the organic light emitting device E, there is no need to expose the protective film **290** to a high-temperature process. Thus, the protective film **290** does not need to be formed of an expensive PI film.

For example, the protective film **290** may be formed of one of polyethylene terephthalate (PET), polymethylmethacrylate (PMMA), polyethylene terephthalate (PEN), polyester (PE), polycarbonate (PC), and polyethersulfone (PES).

Particularly, in the OLED lighting apparatus **200** according to the second aspect, the encapsulation layer **260** is disposed over the active area AA and the non-active area NAA on the buffer layer **215** and the via electrode **280** passes through the encapsulation layer **260** in the non-active area NAA to be electrically connected to the pad **270**.

In the first aspect, since the encapsulation layer **160** is not disposed in the non-active area NAA of the substrate **110**, in which the pad **170** is disposed, as shown in FIG. **3**, the substrate **110** is necessarily required to stably support the pad **170**.

In the second aspect, since the encapsulation layer **260** is disposed over the active area AA and the non-active area NAA on the buffer layer **215**, as shown in FIG. **5** and FIG. **6**, the pad **270** disposed in the non-active area NAA of the buffer layer **215** can be stably secured by the encapsulation layer **260** bonded thereto.

Accordingly, upon tape automated bonding between an FPCB substrate **300** with a COF tape **305** attached thereto and the via electrode **280**, the COF tape **305** does not directly contact the pad **270** but contacts the via electrode **280** connected to the pad **270**, particularly the connection terminal **280***b* of the via electrode **280** on the encapsulation layer **260**, thereby establishing electrical connection between the FPCB substrate **300** and the via electrode **270**. Here, electrical connection between the via electrode **280** and the FPCB substrate **300** may be achieved by tape automated bonding between the connection terminal **280***b* of the via electrode **280** and the COF tape **305**. In this way, the connection terminal **280***b* of the via electrode **280** is electrically connected to the FPCB substrate **300** via the COF tape **305**, whereby a signal from the outside can be applied to the pad **270** connected to the via electrode **280**.

Since tape automated bonding can be performed after the pad **270** disposed in the non-active area NAA of the buffer layer **215** is stably secured by the encapsulation layer **260**, it is possible to omit a substrate formed of an expensive transparent PI film, which would be otherwise disposed under the buffer layer **215**, thereby reducing manufacturing costs.

In addition, since such a substrate can be omitted, a method of forming the auxiliary wires **220**, the organic light emitting device E and the like can be performed at a high temperature exceeding 350° C., thereby improving reliability of the organic light emitting device E. Further, since the buffer layer **215** formed as an inorganic layer such as SiO_x or SiN_x is exposed to a high temperature exceeding 350° C., the buffer layer can exhibit improved properties in terms of strength and hardness.

Next, a method of manufacturing the OLED lighting apparatus according to the second aspect of the present disclosure will be described with reference to the accompanying drawings. FIG. **7** to FIG. **11** are cross-sectional views illustrating a method of manufacturing the OLED lighting apparatus according to the second aspect of the present disclosure.

Referring to FIG. **7**, a buffer layer **215** is formed on a carrier substrate **10** having a sacrificial layer **5**. When an inorganic material such as SiO_x or SiN_x is used for the buffer layer **215**, the buffer layer **215** may be formed by sputtering, and, when an organic material such as photoacryl is used for the buffer layer, the buffer layer **215** may be formed by spin coating.

Next, auxiliary wires **220** are formed in an active area AA on the buffer layer **215**. The auxiliary wires **220** are arranged in the form of a matrix, mesh, hexagon, octagon, circle or the like having a small linewidth over the entire active area AA of the buffer layer **215** to allow uniform voltage to be applied to a first electrode **230**, which will be subsequently fabricated, such that a large area OLED lighting apparatus can emit light with uniform luminance.

For this purpose, the auxiliary wires **220** may be formed of one of Al, Au, Cu, Ti, W, Mo, Cr, and alloys thereof. The auxiliary wires **220** may have a monolayer structure or a multilayer structure.

Next, the first electrode **230** is formed on the auxiliary wires **220**, followed by forming a protective layer **225** on the first electrode **230**. Here, the first electrode **230** may be disposed over the entire active area AA. The first electrode **230** may be formed of a transparent conductive material such as ITO. The protective layer **225** may be formed on the first electrode **230** to surround the auxiliary wires **220**, thereby reducing surface roughness caused by the auxiliary wires **220**. The protective layer **225** may be formed as an inorganic layer, such as SiO_x or SiN_x. Alternatively, the protective layer **225** may be formed as an organic layer such as photoacryl, or may be formed as a plurality of layers including an inorganic layer and an organic layer.

Referring to FIG. **8**, an organic light emitting layer **240** is formed on the protective layer **225** and the first electrode **230**, followed by formation of a second electrode **250** on the organic light emitting layer **240**. Here, the organic light emitting layer **240** may be formed by vapor deposition and the second electrode **250** may be formed by sputtering, without being limited thereto.

Next, an encapsulation layer **260** is formed over the active area AA and the non-active area NAA on the buffer layer **215** having the second electrode **250** formed thereon. Here, the encapsulation layer **260** may be attached to the buffer layer **215** having the organic light emitting device E formed thereon by thermal compression bonding.

The encapsulation layer **260** may include an adhesive layer **262** and a base layer **264** disposed on the adhesive layer **262**. In this way, the encapsulation layer **260** including the adhesive layer **262** and the base layer **264** is disposed in the active region AA of the buffer layer **215** in which the organic light emitting device E is disposed, such that the OLED lighting apparatus can be sealed by the base layer **264** attached via the adhesive layer **262**.

Here, the adhesive layer **262** may be formed of a photocurable adhesive or a heat-curable adhesive. The base layer **264** serves to prevent penetration of moisture or air from the outside and may be formed of any suitable material for performing this function. For example, the base layer **264** may be formed of a polymeric material such as polyethylene terephthalate (PET) or a metallic material such as an aluminum foil, an Fe—Ni alloy, or an Fe—Ni—Co alloy.

As described above, in the second aspect, the encapsulation layer **260** is disposed over the active area AA and the non-active area NAA, whereby the buffer layer **215** in the non-active area NAA can also be stably attached. Accordingly, it is possible to omit a substrate which would otherwise be disposed under the buffer layer **215**.

Next, the carrier substrate **10** having the sacrificial layer **5** is removed from the buffer layer **215** through irradiation with laser beams from below the carrier substrate **10** having the sacrificial layer **5**.

Referring to FIG. **9**, a through-hole TH is formed through the encapsulation layer **260**, the pad **270** and the buffer layer **215** in the non-active area NAA. The through-hole TH may be formed by micro-punching from the upper surface of the encapsulation layer **260** to the buffer layer **215**.

Although the through-hole TH may be formed through a central portion of the pad **270**, it should be understood that the through-hole may also be formed through an edge of the pad **270**. Formation of the through-hole TH allows a central inner surface of the pad **270** to be exposed to the outside.

Referring to FIG. **10**, a protective film **290** is attached to a lower surface of the buffer layer **215** having the through-hole (TH in FIG. **9**) formed therethrough. Here, the protective film **290** disposed under the buffer layer **215** is not necessarily formed and may be omitted if necessary.

Since the protective film **290** is attached to the lower surface of the buffer layer **215** after formation of the organic light emitting device E, there is no need to expose the protective film **290** to a high-temperature process. Thus, the protective film **290** does not need to be formed of an expensive PI film.

For example, the protective film **290** may be formed of one of polyethylene terephthalate (PET), polymethylmethacrylate (PMMA), polyethylene terephthalate (PEN), polyester (PE), polycarbonate (PC), and polyethersulfone (PES).

Next, the through-hole is filled with a metal paste having good electrical conductivity, followed by curing the metal paste to form a via electrode **280**. The metal paste may include at least one selected from among of Ag, Al, Cu, and Au.

The via electrode **280** passes through the encapsulation layer **260** in the non-active area NAA to be connected to the pad **270**.

Here, the via electrode **280** includes a penetration portion **280*a*** and a connection terminal **280*b***.

The penetration portion **280*a*** of the via electrode **280** is disposed to pass through the encapsulation layer **260**, the pad **270**, and the buffer layer **215** in the non-active area NAA to be electrically connected to the pad **270**. Thus, the penetration portion **280*a*** of the via electrode **280** is electrically connected to the pad **270** at the center of the pad **270** in a lateral-contact geometry.

The connection terminal **280*b*** of the via electrode **280** is disposed on an upper surface of the encapsulation layer **260** in the non-active area NAA to be connected to the penetration portion **280*a*** of the via electrode **280**. Accordingly, the connection terminal **280*b*** of the via electrode **280** is disposed on the upper surface of the encapsulation layer **260** to be exposed to the outside.

Referring to FIG. **11**, the via electrode **280** is connected to an FPCB substrate **300**. As a result, an external signal from the FPCB substrate **300** can be applied to the pad **270** through the via electrode **280**.

Here, electrical connection between the via electrode **280** and the FPCB substrate **300** may be achieved by tape automated bonding between the COF tape **305** and the connection terminal **280*b*** of the via electrode **280**. In this way, the connection terminal **280*b*** of the via electrode **208** is electrically connected to the FPCB substrate **300** via the COF tape **305**, such that a signal from the outside can be applied to the pad **270** connected to the via electrode **280**.

Although some aspects have been described herein, it should be understood by those skilled in the art that these aspects are given by way of illustration only and the present disclosure is not limited thereto. In addition, it should be understood that various modifications, variations, and alterations can be made by those skilled in the art without departing from the spirit and scope of the present disclosure.

<List of Reference Numerals>

200: OLED lighting apparatus	215: buffer layer
220: auxiliary wires	225: protective layer
230: first electrode	240: organic light emitting layer
250: second electrode	260: encapsulation layer
262: adhesive layer	264: base layer
270: pad	270a: pad electrode
270b: pad electrode terminal	280: via electrode
280a: penetration portion of via electrode	
280b: connection terminal of via electrode	
E: organic light emitting device	AA: active area
NAA: non-active area	

What is claimed is:

1. An OLED lighting apparatus having an active area and a non-active area, comprising:
- a buffer layer;
- an auxiliary wire disposed on the buffer layer;
- an organic light emitting device including a first electrode disposed on the auxiliary wire and connected to the auxiliary wire and a second electrode stacked on the first electrode, and an organic light emitting layer between the first and second electrodes;
- a pad connected to the first electrode and the second electrode and disposed in the non-active area; and
- an encapsulation layer disposed over the buffer layer to cover the second electrode and the pad.

2. The OLED lighting apparatus according to claim **1**, further comprising a via electrode passing through the encapsulation layer in the non-active area and connected to the pad.

3. The OLED lighting apparatus according to claim **1**, wherein the pad is disposed on at least one side of the buffer layer.

4. The OLED lighting apparatus according to claim **1**, wherein the pad includes:
- a pad electrode disposed at a same layer as the auxiliary wire and formed of a same material as the auxiliary wire; and
- a pad electrode terminal disposed on the pad electrode and formed of a same material as the first electrode.

5. The OLED lighting apparatus according to claim **4**, wherein the pad electrode terminal is disposed on upper and side surfaces of the pad electrode and surrounds the upper and side surfaces of the pad electrode.

6. The OLED lighting apparatus according to claim **1**, wherein the encapsulation layer covers both the active area and the non-active area.

7. The OLED lighting apparatus according to claim **1**, wherein the via electrode includes:
- a penetration portion passing through the encapsulation layer, the pad, and the buffer layer in the non-active area, and connected to the pad; and

a connection terminal disposed on an upper surface of the encapsulation layer in the non-active area, and connected to the penetration portion.

8. The OLED lighting apparatus according to claim **7**, wherein the via electrode is connected to a driving circuit through a connection terminal.

9. The OLED lighting apparatus according to claim **1**, further comprising a protective layer disposed between the first electrode and the organic light emitting layer and covering the auxiliary wire.

10. The OLED lighting apparatus according to claim **9**, further comprising a protective film disposed under the buffer layer and protecting the buffer layer.

11. The OLED lighting apparatus according to claim **9**, wherein the protective layer is covers the auxiliary wire and reduces a step coverage caused by the auxiliary wire.

12. The OLED lighting apparatus according to claim **9**, wherein the protective layer is covers the auxiliary wire and reduces a step coverage caused by the auxiliary wire.

13. The OLED lighting apparatus according to claim **1**, wherein the organic light emitting layer has a tandem structure.

14. An OLED lighting apparatus having an active area and a non-active area, comprising:

a buffer layer;

an auxiliary wire disposed on the buffer layer;

an organic light emitting device including a first electrode disposed on the auxiliary wire and connected to the auxiliary wire, a second electrode stacked on the first electrode and an organic light emitting layer disposed between the first and second electrodes;

an encapsulation layer disposed over the buffer layer and having an opening;

a pad connected to the first and second electrodes and disposed in the non-active area and contacting a side of the buffer layer; and

a via electrode passing through the opening of the encapsulation layer in the non-active area and connected to the pad.

15. The OLED lighting apparatus according to claim **14**, wherein the via electrode includes:

a penetration portion passing through the encapsulation layer, the pad, and the buffer layer in the non-active area, and connected to the pad; and

a connection terminal disposed on an upper surface of the encapsulation layer in the non-active area, and connected to the penetration portion.

16. The OLED lighting apparatus according to claim **14**, further comprising a protective layer disposed between the first electrode and the organic light emitting layer.

17. The OLED lighting apparatus according to claim **16**, further comprising a protective film disposed under the buffer layer and protecting the buffer layer.

* * * * *